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Western Spruce Budworm Silvicultural Demonstration Area Project, Carson National Forest

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WESTERN SPRUCE BUDWORM SILVICULTURAL DEMONSTRATION AREA PROJECT

Carson National Forest
New Mexico

Report No. 1

by

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I. INTRODUCTION

The western spruce budworm, *Choristoneura occidentalis* Freeman, is a major defoliator pest of Rocky Mountain Douglas-fir, *Pseudotsuga menziesii* var. *glauca*, and true firs, *Abies* spp. throughout the Southwestern, Rocky Mountain, and Northwestern Regions. Budworm larvae feed principally in buds and on the foliage of the current year. Sustained heavy attacks cause nearly complete defoliation in 4 to 5 years and result in appreciable growth loss, tree deformity, top-killing, and tree mortality. Cone and seed production are also significantly reduced.

Past research along with innumerable observations by field foresters suggests that silvicultural practices can have a decided effect on the amount of stand damages caused by the western spruce budworm. For example, 1) favoring intolerant species in silvicultural treatments will reduce budworm damages since it is always the more shade tolerant host which suffers the greater damage (Williams 1966, 1967; Williams et al. 1971; Johnson and Denton 1975); 2) thinnings and other types of stocking reduction treatments would result in less budworm damage by improving tree growth and reducing competition since dense stands have been shown to incur more damage by the budworm than open stands (Fauss and Pierce 1969; Williams et al. 1971); and 3) prompt removal of host overstories and favoring even-aged stand structures can be considered preventive management practices for the budworm since understory host trees are especially vulnerable to budworm damage because of their relatively poor physiological condition and because they are subject to inundation by larvae dropping from the host overstory trees (Johnson and Denton 1975).

The Canada/U.S. Spruce Budworms Program (CANUSA) is an accelerated research and development program chartered to design and evaluate management strategies specifically designed for control of the spruce budworms and/or management of budworm-susceptible forests. In 1980, the Carson National Forest, in conjunction with Forest Pest Management and with the assistance of CANUSA, established a silvicultural demonstration area on the Taos Ranger District to evaluate the effectiveness of several silvicultural management systems. The intent was to minimize budworm damages while meeting other timber production objectives. Silvicultural management systems demonstrated include 1) clearcutting with planting, 2) shelterwood seed step cutting with planting, 3) shelterwood seed step cutting with protection of advanced regeneration, and 4) shelterwood final removal cutting.

II. OBJECTIVES

The objectives of this western spruce budworm silvicultural demonstration area project are:

1. To demonstrate the effect of certain state-of-the-art silvicultural systems on resident western spruce budworm populations and on the resultant damage during and subsequent to an ongoing outbreak.

2. To demonstrate the relative effectiveness of these treatments on achieving timber production objectives.

3. To estimate and compare budworm population densities before and after treatment and for 4 to 5 years thereafter until the project is either terminated or the outbreak collapses from natural causes.

4. To display a comparison between the unmanaged forest and various forest management and stand regeneration techniques.

5. To gain a wider acceptance of preventive management strategies for use against the western spruce budworm and other important forest pests.

III. DESCRIPTION OF PROJECT AREA

A. Location

The project area is located on the Taos Ranger District of the Carson National Forest. It is identified as stand #07 of compartment #206 according to District records. The stand is situated on a broad ridge which extends north from Don Fernando Peak towards Taos Canyon. Included are side slopes averaging 20 percent and generally facing northeast. The elevation ranges from 8,400 to 9,800 feet (see Appendix A - Project Area Map).

B. Outbreak History

The project area is currently infested with western spruce budworm as part of a general outbreak which was first detected in 1975. In order to accurately portray the impact of this outbreak, sampling units were installed at selected locations across the Carson National Forest in 1978 (Stein 1980). One such sampling unit is located within the demonstration area. Data from this damage assessment unit indicates that the project area received little or no defoliation prior to 1978. From 1978 to 1979, average current year's defoliation of overstory Douglas-fir rose from 47 to 80 percent. Egg mass densities also rose sharply indicating that the damage would likely intensify in 1980.

C. Stand Conditions

The project area includes stand variations which are typical of the Southwestern mixed conifer type (Jones 1974) in terms of species composition, size class diversity, and infection level of Douglas-fir dwarf mistletoe (Arceuthobium douglasii). The stand is composed principally of Rocky Mountain Douglas-fir, white fir (Abies concolor), and quaking aspen (Populus tremuloides). Lesser amounts of Engelmann spruce (Picea engelmannii), blue spruce (Picea pungens), and corkbark (Abies lasiocarpa var. arizonica) are found associated with the more mesic sites. Remnant old growth ponderosa pine (Pinus ponderosa) occur in two small overwood groups.

The stand has an irregular age-size class structure which is caused primarily by prior extensive salvage harvesting. The broken overstory is formed by mature and overmature sawtimber. Scattered poletimber occurs under this layer as do seedlings and saplings. Understory stocking improves with canopy openings and past ground disturbance.

Douglas-fir dwarf mistletoe, the western spruce budworm, and certain fungal diseases are the most important debilitating agents in the stand. The dwarf mistletoe (Arceuthobium douglasii) occurs throughout the stand, but becomes extremely severe in the northern and western portions. In these areas, nearly all Douglas-fir trees, regardless of size or position, show brooming, whereas elsewhere this response is scattered in the overwood. Feeding damage by the western spruce budworm (Choristoneura occidentalis) is most apparent in the suppressed, overtopped white fir, Douglas-fir, and Engelmann spruce. Less damage has occurred to seedlings and saplings growing in openings or under quaking apsen. Defoliation is quite noticeable in the overstory, but little top-kill or mortality can be attributed to the current infestation. Hypoxylon canker (H. mammatum) and the false tinder fungus (Fomes ignarius) are infecting many aspen clones and inducing windthrow in localized situations. Shoestring root rot (Armillaria mellea) and other unidentified root diseases were found causing crown deterioration and mortality in Douglas-fir and white fir. Indian paint fungus (Echinodontium tinctorium) is causing stem decay in older white fir.

An intensive stand examination was performed on the project area during the first week of August 1980. The area was first stratified into substands or treatment units based on variations in species composition and stand structure observed on aerial photographs. Following ground reconnaissance, five treatment units were chosen for the demonstration. These are depicted on the Project Area Map (Appendix A). Each treatment unit was sampled separately prior to treatment according to procedures described in Appendix E.

Table A and B compare the five treatment units in terms of stocking and species composition.

Table A - Pre-treatment stocking levels and species composition for treatment units by basal area per acre for trees ≥ 5 inches in d.b.h., Western Spruce Budworm Silvicultural Demonstration Area, Carson National Forest.

Treatment Unit	SPECIES						
	Douglas-fir	White fir	Corkbark fir	Spruce	Ponderosa pine	Aspen	Total
Clearcut	62	14	0	0	4	10	90
Shel-Plant	110	4	0	0	0	4	118
Shel-Advanced	27	16	2	4	0	20	69
Overstory Removal	34	8	0	0	0	12	54
Control	76	4	0	0	2	8	90

Table B - Pre-treatment stocking levels in numbers of trees per acre for trees < 5.0 d.b.h. and species composition for treatment units, Western Spruce Budworm Silvicultural Demonstration Area, Carson National Forest.

Treatment Unit	SPECIES						
	Douglas-fir	White fir	Corkbark fir	Spruce	Ponderosa pine	Aspen	Total
Clearcut	390	270	0	0	10	740	1,410
Shel-Plant	180	160	0	0	0	620	960
Shel-Advanced	156	56	0	44	0	1,433	1,689
Overstory Removal	280	290	0	0	0	820	1,390
Control	340	90	0	10	0	620	1,060

Expanded stand and stock tables for each unit are presented in Appendix B.

Douglas-fir is the most abundant host tree for budworm on the project area. Using this species as an index to stand damage, tables C and D compare pre-treatment budworm damage levels for each treatment unit.

Table C - Percent of the Douglas-fir basal area stocking for treatment units by defoliation class for trees ≥ 5.0 inches d.b.h., Western Spruce Budworm Silvicultural Demonstration Area, Carson National Forest.

TREATMENT UNIT	CURRENT MIDCROWN DEFOLIATION			
	NONE (0%)	LIGHT (1-25%)	MODERATE (26-75%)	SEVERE (76-100%)
Clearcut	0	36	31	33
Shel-Plant	0	5	33	62
Shel-Advanced	7	13	40	40
Overstory Removal	0	0	65	35
Control	0	7	37	56

Table D - Percent of Douglas-fir trees per acre stocking for treatment units by defoliation class for trees < 5.0 inches d.b.h., Western Spruce Budworm Silvicultural Demonstration Area, Carson National Forest.

TREATMENT UNIT	CURRENT MIDCROWN DEFOLIATION			
	NONE (0%)	LIGHT (1-25%)	MODERATE (26-75%)	SEVERE (76-100%)
Clearcut	6	23	51	20
Shel-Advanced	0	0	61	39
Shel-Plant	7	0	93	0
Overstory Removal	0	25	64	11
Control	0	3	68	29

More detailed budworm damage tables, including all host species, are presented in Appendix C.

Other damaging agents or conditions appear to be sporadically distributed across the treatment units. The one notable exception is Douglas-fir dwarf mistletoe which is concentrated in the area to be clearcut and the control unit. Stand damage tables, exclusive of budworm, are presented in Appendix D.

D. Insect Conditions

Larvae of western spruce budworm were sampled on each treatment unit in order to obtain an index to the density of the feeding population. Larval sampling methods are described in Appendix F. The sampling was performed June 19-24, 1980, when approximately 20 percent of the population was in the fifth instar. Larvae were counted on three tree strata: seedling Douglas-fir, 1.5 to 3.0 feet tall; sapling Douglas-fir, 1.0 to 4.9 inches d.b.h.; and dominant-codominant Douglas-fir, 30 to 50 feet tall.

Average larval densities per 100 buds sampled in the proposed treatment units ranged from 11.5 to 18.2 for seedlings, 14.8 to 22.8 for saplings, and 15.5 to 21.9 for dominant-codominant Douglas-firs, and averaged 13.9, 21.7, and 21.9, respectively. These data are summarized by treatment unit and project area in Table E.

Table E. Summaries of pre-treatment larval densities per 100 buds for seedling, sapling, and overstory Douglas-firs, Western Spruce Budworm Silvicultural Demonstration Area, Carson National Forest.

Treatment Unit	Seedlings DF		Sapling DF		Overstory DF	
	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S
Clearcut	18.2	9.3	14.8	5.9	15.5	9.05
Shel-Plant	12.4	7.2	32.7	8.1	33.9	13.1
Shel-Advanced	No Sample		18.9	11.1	15.8	7.07
Overstory Removal	11.5	11.6	19.4	15.4	22.6	9.7
Control	13.6	6.8	22.8	10.3	21.9	18.8
Average for Project Area	13.9	2.9	21.7	6.8	21.9	7.5

Egg masses of western spruce budworm were sampled on each of the treatment units in mid-August 1980. It appeared at this time that

the moth flight period was complete and that egg laying had terminated for the season. Sampling procedures for egg masses are described in Appendix F. Egg mass densities represent an index to next year's feeding population of larvae.

The average number of egg masses per meter square of foliage collected from the proposed treatment units ranged from 3.7 to 11.1 for seedlings, 13.7 to 30.4 for saplings, and 76.6 to 111.8 for dominant-codominant Douglas-firs, and averaged 6.5, 20.3, and 85.4, respectively. These data are summarized by treatment unit and project area in Table F.

Table F. Summaries of pre-treatment egg mass densities per meter square of foliage for seedling, sapling, and overstory Douglas-firs, Western Spruce Budworm Silvicultural Demonstration Area, Carson National Forest.

Treatment Unit	Seedlings DF		Sapling DF		Overstory DF	
	$\overline{X}$	S	$\overline{X}$	S	$\overline{X}$	S
Clearcut	3.7	11.7	13.7	15.1	76.6	24.9
Shel-Plant	11.1	24.5	30.4	22.6	56.7	23.3
Shel-Advanced	7.4	23.4	23.4	28.0	96.7	42.8
Overstory Removal	No Sample		No Sample		85.4	43.4
Control	3.7	6.9	13.7	15.8	111.8	69.9
Avg. for Project Area	6.5	3.5	20.3	8.1	85.4	20.8

Egg mass densities collected from dominant-codominant Douglas-fir sample trees indicate that larval densities and resultant defoliation would be high in all units in 1981[1/].

IV. SILVICULTURAL TREATMENTS

Four different silvicultural treatments were conducted on the demonstration area. These treatments represent the full range of feasible silvicultural options for regenerating an even-aged stand while employing pest protection strategies. Sustained timber produc-

1/ McKnight, M. E., J. F. Chansler, D. B. Cahill, and H. W. Flake, Jr. 1970. Sequential plant for western spruce budworm egg mass surveys in the central and southern Rocky Mountains. USDA Forest Service Res. Note RM-174. 5 pp.

tion is assumed to be the only management objective for the area. Uneven-aged systems were not proposed because a continuous high forest cover is not necessary for achieving management objectives, and such systems are difficult and costly to implement and regulate. The seed tree method was not considered a viable alternative because western spruce budworm is likely to destroy the cone crops of its host species and there are insufficient numbers of ponderosa pine seed trees. The four prescribed treatments include clearcutting with planting, shelterwood seed step cutting with planting, shelterwood seed step cutting with protection of advance regeneration, and shelterwood final removal cutting. Silvicultural prescriptions, with special reference to the implied spruce budworm protection strategies, are summarized below.

A. Unit No. 1: Clearcut - Plant

Site Data: Area, 20 acres; elevation, 9,300 to 9,450 feet; slope, 5 to 10 percent; physiographic position, ridgetop; aspect, level; productivity, 40 to 50 feet^3 per acre per year at culmination.

Stand Data: Structure - The stand is irregular uneven-aged and multistoried. Overstory sawtimber is 150 to 300 years old; intermediate poletimber is 140 to 160 years old; saplings are 70 to 90 years old; suppressed seedlings are 20 to 50 years old.

Composition: Douglas-fir is the most abundant conifer. White fir is scattered, ponderosa pine is occasional, and quaking aspen is common mostly in smaller size classes. Both Douglas-fir and white fir occur in the understory.

Density: Total basal area per acre equals 98 square feet of which two-thirds is Douglas-fir. Seedlings and saplings number 1,400 per acre; half are quaking aspen.

Condition: There is severe dwarf mistletoe infection in Douglas-fir. Current spruce budworm defoliation is severe on white fir and moderate on Douglas-fir. Older dead tops on white fir were noted. Two root disease centers were detected involving Douglas-fir and white fir.

Growth: The estimated periodic annual increment is 31 feet^3 per acre per year, but this does not account for current defoliation or deterioration. Understory conifers are severely suppressed.

Diagnosis: The existing stand cannot be manipulated to meet timber production objectives because of its age, dwarf mistletoe infection, budworm damage prognosis and declining growth. Regeneration by clearcutting with planting is an efficient means of controlling dwarf mistletoe and species composition in the new stand. The target stand described at maturity is as follows: structure, even-aged; composition, 40 percent Douglas-fir, 40 percent ponderosa pine, 20 percent quaking aspen; density, 60 square feet per acre after

thinning; condition, no dwarf mistletoe, periodic light defoliation of Douglas-fir by spruce budworm, no top-killing, no root disease mortality; growth, 50 $feet^3$ per acre per year at culmination, all overstory trees vigorous.

Budworm Management Strategies: Creation of an even-aged structure will increase larval dispersal mortality and prevent crop trees from being maintained in vulnerable overtopped positions. All mature trees are removed thus eliminating budworm overwintering sites and preferred oviposition sites. Species composition is adjusted to eliminate white fir, the more susceptible species, and favor ponderosa pine, an intolerant nonhost. The food supply per acre is reduced and larval dispersal to nonhost should increase budworm mortality. Periodic regulation of stand density will maintain tree vigor thereby decreasing budworm food quality.

Prescribed Treatment Sequence:

Year 0 - Clearcut with no protection required for submerchantable sized trees.

Year 1 - Hand slash residual trees and broadcast burn for site preparation; burn intensity should be such that the larger slash is conserved to provide planting sites.

Year 2 - Hand plant 450 2-0 seedlings per acre, half Douglas-fir and half ponderosa pine; use available shade and artificially shade all Douglas-fir.

Year 2+4 - Conduct survival exams after the summer dry season; increase surveillance if pocket gopher activity is noted on first exam; minimum acceptable stocking is 300 trees per acre including up to 20 percent quaking aspen sprouts.

Year 17 - Precommercial thin to 300 trees per acre.

Subsequent harvests - Commercial thin to 54 square feet per acre when average stand diameter equals 8 inches, later thinnings to 50 square feet per acre should occur at 30-year intervals until culmination of mean annual increment.

B. <u>Unit No. 2: Shelterwood - Plant</u>

Site Data: Area, 22 acres; elevation, 9,200 to 9,500 feet; slope, 25 to 30 percent; physiographic position, upper sideslopes; aspect, northeast; productivity, 45 to 55 $feet^3$ per acre per year at culmination.

Stand Data: Structure - The stand is essentially two-storied. Overstory poletimber and sawtimber is 120 to 200 years old; understory seedlings and saplings range from 30 to 110 years in age.

Composition: Douglas-fir is the most abundant conifer. White fir is very scattered. Quaking aspen occurs along the northern and eastern boundaries of the unit.

Density: Total basal area per acre equals 125 square feet of which 90 percent is Douglas-fir. Seedlings and saplings number 960 per acre, 35 percent are Douglas-fir and white fir; the remainder is quaking aspen.

Condition: Dwarf mistletoe infection is light in Douglas-fir along the western edge. Current spruce budworm defoliation is moderate to severe on Douglas-fir and severe on white fir. Overtopped trees are especially defoliated and suppressed. Root disease is suspected in some Douglas-fir because of unhealthy crown symptoms.

Growth: The estimated periodic annual increment is 35 $feet^3$ per acre per year, but this does not account for current defoliation. Understory conifers have less than 1 inch current height growth.

Diagnosis: The existing stand cannot be manipulated to meet timber production objectives. Stand growth is declining because of age and budworm damage. Intermediate treatments would not ameliorate these conditions. Regeneration cutting is thus warranted. The shelterwood method can be used to provide shade during the regeneration period and seed after the budworm outbreak subsides. The advance regeneration is in very poor condition, distributed unevenly, and highly susceptible to budworm. Planting under the shelterwood will assure prompt establishment of desired species. The target stand described at maturity is: structure, even-aged; composition, 45 percent Douglas-fir, 45 percent ponderosa pine, 10 percent quaking aspen; density, 70 square feet per acre after thinning; condition, no dwarf mistletoe, no root disease mortality, periodic light defoliation of Douglas-fir by spruce budworm, but no top-killing; growth, 55 $feet^3$ per acre per year at culmination, all overstory crop trees vigorous.

Budworm Management Strategies: Creation of an even-aged structure will increase larval dispersal mortality. Immediate replacement of existing multisized understory with small seedlings which represent smaller targets will increase larval dispersal mortality. Overwood density reduction and prompt final removal will reduce sources of dispersing larvae. Exposure of mature residual Douglas-fir to sunlight after seed cutting may, however, increase the preferred oviposition sites temporarily. Using defoliation as criteria for leave tree selection may result in increased genetic resistance to feeding. Final overwood removal after regeneration establishment will eliminate preferred oviposition and overwintering sites. Introducing ponderosa pine and excluding white fir in the new stand will reduce the budworm food quantity per acre and result in increased dispersal loss of larvae. Subsequent regulation of stand density by periodic thinnings will maintain tree vigor, thereby decreasing budworm food quality.

Prescribed Treatment Sequence:

Year 0 - Shelterwood seedcut retaining 35 to 40 square feet of basal area per acre in the larger diameter classes of Douglas-fir; select leave trees based on crown and foliage appearance as well as uniform spacing of 40 to 60 feet.

Year 1 - Destroy advance regeneration and scarify ground while spot machine piling slash, burn slash piles.

Year 2 - Underplant 400 seedlings per acre, half Douglas-fir and half ponderosa pine; conduct fall survival exam.

Year 2+4 - Conduct survival exams after summer dry seasons, make note of cone crop potentials and budworm damage levels, minimum acceptable stocking is 350 trees per acre, including up to 10 percent quaking aspen.

Year 7 - Conduct final overwood removal harvest.

Year 17 - Precommercial thin to 300 trees per acre.

Subsequent harvests - When average stand diameter reaches 8 inches, thin to 63 square feet per acre, later thinnings to 70 square feet per acre should occur at 30-year intervals until mean annual increment culminates.

C. Unit No. 3: Shelterwood - Advanced

Site Data: Area, 36 acres; elevation, 9,280 to 9,600 feet; slope, 20 to 25 percent; physiographic position, upper sideslopes; aspect, east; productivity, 50 to 60 $feet^3$ per acre per year at culmination.

Stand Data: Structure - The stand is uneven-aged with somewhat balanced distribution between size classes. Overstory sawtimber is 120 to 200 years old, intermediate poletimber is 70 to 170 years old, and understory seedlings and saplings range from 10 to 60 years in age.

Composition: Douglas-fir is the most abundant conifer. White fir and quaking aspen are also prevalent. Minor amounts of spruce and corkbark fir occur throughout the stand.

Density: Total basal area per acre is 75 square feet; Douglas-fir accounts for 30 square feet, white fir 18 square feet, and aspen 21 square feet. Understory seedlings and saplings number nearly 1,700 per acre of which 1,400 are aspen sprouts, 155 Douglas-fir, 55 white fir, and 44 spruce.

Condition: Current spruce budworm defoliation ranges from none to severe on Douglas-fir. On white fir defoliation is moderate

to severe. Trees in canopy openings have less defoliation than those in intermediate or overtopped positions. Indian paint fungus has infected the older white fir and the older aspen is deteriorating from stem cankers and heart rot. One apparent root disease center was detected involving white fir and aspen.

Growth: The estimated periodic annual increment is 42 $feet^3$ per acre per year. This figure, however, is gross in that it neither accounts for the current defoliation or deterioration from rot. The height growth of understory conifers is quite variable ranging from 1 inch to over 14 inches.

Diagnosis: The stand owes its present structure to past harvesting activities. In canopy openings and where overwood stocking was reduced, regeneration of Douglas-fir, white fir, spruce, and aspen is established. Elsewhere, seedlings are nonexistent or severely damaged by budworm and suppression. A portion of this understory can serve timber production objectives. The overstory, however, is too old and stocking too low to be manipulated for the purpose of improving stand growth and yield. Regeneration cutting is warranted. Applying a shelterwood seed step cutting will provide gradual release of understory crop trees while maintaining a potential seed source on the site. Where understory crop tree stocking is adequate, removal cutting can occur. The target stand at maturity is as follows: structure, even-aged; composition, 50 percent Douglas-fir, 20 percent quaking aspen, 15 percent white fir, 15 percent blue spruce; density, 80 square feet per acre after thinning; condition, periodic light defoliation of host conifers by spruce budworm with no top-killing, otherwise no pest problems; growth, 60 $feet^3$ per acre per year at culmination, all overstory trees vigorous.

Budworm Management Strategies: The ultimate creation of an even-aged structure will increase larval dispersal mortality during future outbreaks. The immediate reduction of host overstory trees will reduce sources of larvae dispersing to crop trees. Favoring the least defoliated trees for retention as a seed source may result in some improvement in the genetic resistance to budworm feeding in the new stand. The species composition goals do not reflect a lower susceptibility to budworm over the present stand. This objective is based on securing natural regeneration exclusive of planting. Douglas-fir, being the least susceptible host in the mixed conifer type, is favored, and corkbark fir is excluded. Temporarily there may be an increase in preferred oviposition sites as residual seed trees become isolated and exposed, but after removal cutting, both oviposition sites and overwintering sites will be drastically reduced. The release of understory trees should make them less vulnerable to damage. Subsequent thinnings to maintain vigor will also reduce vulnerability to damage and budworm food quality while maintaining moderate dispersal-related mortality levels.

Prescribed Treatment Sequence:

Year 0 - Shelterwood seedcut retaining an average of 25 square feet of basal area per acre; removal cutting should occur where crop tree understory stocking is adequate; select leave trees based on crown and foliage appearance favoring the least damaged conifers; scarify areas not stocked with seedlings and saplings during logging operations; protect advance seedlings and saplings from damage.

Year 1 - Spot machine pile generated slash in stand openings and burn slash piles.

Year 2+4 - Conduct stocking surveys of existing seedlings, saplings, and new natural regeneration; minimum acceptable stocking is 350 trees per acre.

Year 7 - Conduct final removal harvest of all overstory trees.

Year 8 - Precommercial thin to 300 trees per acre.

Subsequent harvests - When average stand diameter reaches 8 inches, thin to 72 square feet per acre, later thinnings to 80 square feet per acre should occur at 30-year intervals until culmination of mean annual increment.

D. <u>Unit No. 4: Overstory Removal</u>

Site Data: Area, 36 acres; elevation, 9,160 to 9,400 feet; slope, 10 to 20 percent; physiographic position, middle slopes; aspect, northeast and east; productivity, 45 to 55 feet^3 per acre per year at culmination.

Stand Data: Structure - This stand has an irregular uneven-aged structure with a broken to sparse canopy. Overstory sawtimber is 120 to 200 years old and the poletimber is 70 to 180 years old. Seedlings are generally less than 30 years old, but saplings attain ages of up to 100 years.

Composition: Douglas-fir is the most abundant tree comprising over half of the basal area stocking. White fir and quaking aspen are also found in all canopy positions.

Density: Total basal area stocking is 66 square feet per acre. Douglas-fir accounts for 38 square feet and both white fir and aspen have 14 square feet of stocking each. Seedlings and saplings number about 1,400 per acre, 60 percent are aspen sprouts and the remaining 40 percent is composed equally of Douglas-fir and white fir.

Condition: Current spruce budworm defoliation ranges from light to severe on Douglas-fir and white fir with the latter species generally suffering more damage. The smaller trees, especially those

in canopy openings, tend to be less damaged by the budworm. Some white fir saplings exhibit dead tops presumably from previous spruce budworm outbreaks. Many of the older aspen have Hypoxylon canker disease.

Growth: The estimated periodic annual increment is 35 $feet^3$ per acre per year. This figure does not account for the current defoliation-induced growth suppression. The current height increment on seedlings and saplings is quite variable from less than 1 inch to 12 inches.

Diagnosis: The existing stand structure is a result of past harvesting activities which left clumps and patches of overstory trees and many open areas. Regeneration has become established in the openings and where the ground was scarified. Much of the regeneration is healthy with only minor defoliation at this time. The existing stand can be manipulated to meet timber production objectives. Complete removal of the overstory with supplemental planting can provide a fully stocked even-aged stand of desirable species composition. The target stand at maturity is as follows: structure, even-aged; composition, 30 percent Douglas-fir, 20 percent quaking aspen, 20 percent white fir; density, 70 square feet per acre after thinning; condition, periodic light defoliation of Douglas-fir and white fir by spruce budworm, no top-killing, otherwise healthy and vigorous; growth, 55 $feet^3$ per acre per year at culmination.

Budworm Management Strategies: Creation of an even-aged structure will increase larval dispersal mortality. Complete removal of the host overstory will reduce sources of dispersing larvae and eliminate preferred oviposition and overwintering sites. Targeting a species mix including ponderosa pine and aspen and favoring Douglas-fir over white fir will reduce the budworm's food quantity and quality. Release of young host trees should also degrade the food quality, and maintenance of stand vigor by periodic stocking regulation will provide for low food quality and high dispersal loss of larvae in the future.

Prescribed Treatment Sequence:

Year 0 - Harvest all overstory trees while protecting the advance regeneration of seedlings and saplings.

Year 1 - Slash trees severely damaged by logging equipment or budworm and all residual nonmerchantable poletimber; favor retaining the smaller younger trees on a 6'X6' spacing; interplant ponderosa pine in all understocked areas on a 10'X10' spacing (436 trees per acre).

Year 2+4 - Conduct stocking and survival examinations; monitor pocket gopher damage.

Year 7 - Conduct precommercial thinning with the objective of regulating density and species composition; target stand is 300 trees per acre, 30 percent Douglas-fir, 30 percent ponderosa pine, 20 percent white fir, and 20 percent aspen.

Subsequent harvests - First commercial thinning should occur when average stand diameter is 8 inches, residual basal area per acre equals 63 square feet. Later thinnings to 70 square feet per acre should occur at 30-year intervals until culmination of mean annual increment.

V. MONITORING AND EVALUATION

The western spruce budworm population will be sampled annually on each of the five units. Estimates will be made of egg mass and larval density for each tree strata; seedlings, saplings, and overstory Douglas-fir. Formal stand examinations, including budworm damage assessments, will be made at 2-year intervals beginning the fall after treatments are completed. Logging began on the area in the fall of 1980 and the initial treatments are expected to be installed by spring 1982.

Evaluation of the imposed silvicultural treatments will simply be made by comparing species composition, stand structure, stocking, growth rate, and incidence of budworm damage between the treatment units. Observed differences cannot be attributed solely to the silvicultural treatment applied since initial site and stand conditions were variable. However, these observations will provide valuable insight into the feasibility of applying recommended silvicultural strategies for budworm management on specific sites.

Unit No. 5 is to be left untreated and will serve as an example of the development of an unmanaged stand during the course of a spruce budworm outbreak. Insect population trends in this unmanaged stand will be compared to indicated trends in the treated areas to determine the effect of the applied silvicultural treatments on insect densities.

VI. LITERATURE CITED

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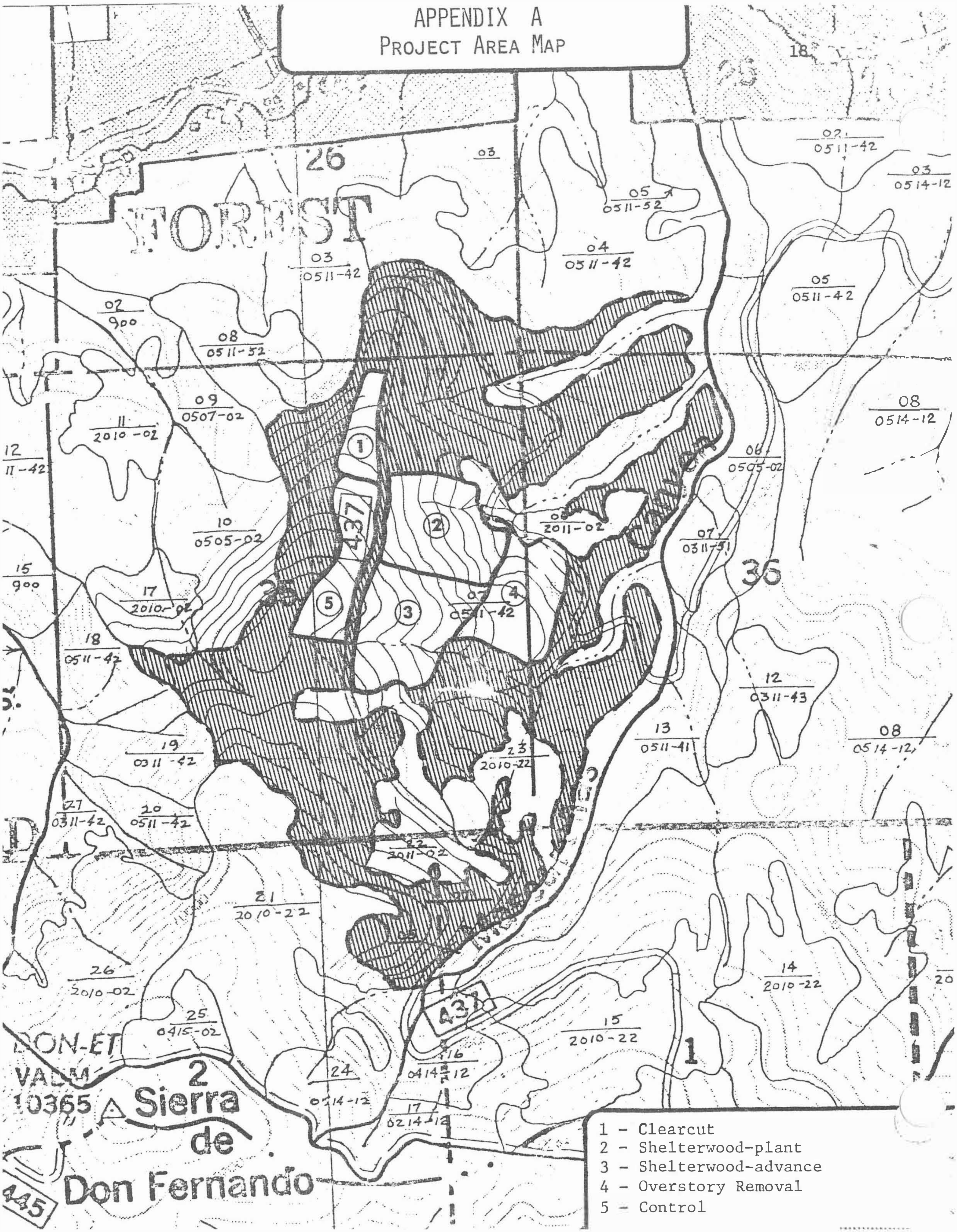
A P P E N D I C E S

APPENDIX A
Project Area Map



1 - Clearcut
2 - Shelterwood-plant
3 - Shelterwood-advance
4 - Overstory Removal
5 - Control

APPENDIX B

Stand and Stock Tables

The following tables, 1-5, display stand structures by diameter classes and species composition in terms of number of trees (T), basal area (BA), cubic foot volume (CFV), board foot volume (BFV), and gross periodic annual cubic foot increment (PAI) for each unit. These tables include only live trees and all values are expressed per acre. Since the radial growth of aspen was not field sampled, the PAI estimates are biased and thus should be used for comparative analysis only. Data was compiled by the computer program "INDIDS" (Bousfield 1980).

Table 1

UNIT #1 CLEARCUT

Diameter Class	Species						Total
	DF	WF	CBF	S	PP	ASP	
0-4.9							
T	390.0	270.0	0	0	10.0	740.0	1,410.0
BA	4.2	1.3	0	0	0.1	2.3	7.9
5-8.9							
T	21.5	13.0	0	0	0	24.9	59.4
BA	4.0	4.0	0	0	0	6.0	14.0
CFV	28.2	40.2	0	0	0	88.4	156.8
PAI	1.5	2.0	0	0	0	3.4	6.9
9-11.9							
T	20.7	9.7	0	0	0	3.1	33.5
BA	12.0	6.0	0	0	0	2.0	20.0
CFV	208.8	107.0	0	0	0	44.1	359.9
BFV	601.0	334.5	0	0	0	184.2	1,119.6
PAI	5.2	2.3	0	0	0	0.9	8.4
12 +							
T	29.7	3.1	0	0	3.1	2.1	37.9
BA	46.0	4.0	0	0	4.0	2.0	56.0
CFV	1,082.6	84.2	0	0	79.8	48.6	1,295.2
BFV	5,321.3	403.1	0	0	347.6	224.3	6,296.4
PAI	12.9	1.9	0	0	0.7	0.8	16.2
TOTALS							
T	461.9	295.7	0	0	13.1	770.1	1,540.8
BA	66.2	15.3	0	0	4.1	12.3	97.9
CFV	1,319.6	231.4	0	0	79.8	181.1	1,811.9
BFV	5,922.3	737.5	0	0	347.6	408.5	7,416.0
PAI	19.6	6.1	0	0	0.7	5.1	31.5

Table 2

UNIT #2 SHELTERWOOD-PLANT

Diameter Class	Species DF	WF	CBF	S	PP	ASP	Total
0-4.9							
T	180.0	160.0	0	0	0	620.0	960.0
BA	5.3	1.3	0	0	0	0.3	6.9
5-8.9							
T	96.6	0	0	0	0	13.3	109.9
BA	26.6	0	0	0	0	4.0	30.0
CFV	326.1	0	0	0	0	73.4	399.5
PAI	5.6	0	0	0	0	1.4	7.0
9-11.9							
T	83.6	2.6	0	0	0	0	86.2
BA	48.0	2.0	0	0	0	0	50.0
CFV	855.0	43.5	0	0	0	0	898.5
BFV	2,495.4	175.6	0	0	0	0	2,671.1
PAI	13.5	0.8	0	0	0	0	14.3
12 +							
T	33.1	2.1	0	0	0	0	35.2
BA	36.0	2.0	0	0	0	0	38.0
CFV	750.1	42.2	0	0	0	0	792.3
BFV	3,317.2	183.1	0	0	0	0	3,500.3
PAI	12.9	0.7	0	0	0	0	13.6
TOTALS							
T	393.2	164.8	0	0	0	633.3	1,191.3
BA	115.3	5.3	0	0	0	4.3	124.9
CFV	1,931.3	85.7	0	0	0	73.4	2,090.3
BFV	5,812.6	358.8	0	0	0	0	6,171.4
PAI	31.9	1.6	0	0	0	1.4	34.9

Table 3

UNIT #3 SHELTERWOOD-ADVANCE

Diameter Class	DF	WF	CBF	S	PP	ASP	Total
	Species						
0-4.9							
T	155.6	55.6	0	44.4	0	1,433.3	1,688.9
BA	3.4	1.9	0	0	0	1.0	6.3
5-8.9							
T	18.6	21.8	0	0	0	20.6	61.0
BA	4.4	6.7	0	0	0	6.7	17.8
CFV	47.8	65.0	0	0	0	149.9	262.7
PAI	4.4	4.1	0	0	0	5.3	13.9
9-11.9							
T	17.9	4.1	0	0	0	13.2	35.2
BA	11.1	2.3	0	0	0	6.7	20.0
CFV	216.7	24.5	0	0	0	161.6	402.8
BFV	723.4	16.2	0	0	0	643.8	1,383.4
PAI	5.3	0.8	0	0	0	5.1	11.3
12 +							
T	6.8	4.6	2.0	2.9	0	4.5	20.8
BA	11.1	6.7	2.2	4.4	0	6.6	31.1
CFV	281.9	193.7	52.8	120.0	0	241.2	889.6
BFV	1,423.1	1,002.6	253.6	602.3	0	1,212.8	4,494.3
PAI	4.5	4.3	0.7	3.3	0	4.6	17.4
TOTALS							
T	198.8	86.1	2.0	47.3	0	1,471.7	1,806.0
BA	30.0	17.5	2.2	4.4	0	21.0	75.2
CFV	546.4	283.2	52.8	120.0	0	552.7	1,555.0
BFV	2,146.5	1,018.8	253.6	602.3	0	1,856.6	5,877.7
PAI	14.2	9.3	0.7	3.3	0	15.1	42.6

Table 4

UNIT #4 OVERSTORY REMOVAL

Diameter Class	Species DF	WF	CBF	S	PP	ASP	Total
0-4.9							
T	280.0	290.0	0	0	0	820.0	1,390.0
BA	4.4	6.0	0	0	0	1.9	12.2
5-8.9							
T	15.2	25.2	0	0	0	4.7	45.1
BA	6.0	6.0	0	0	0	2.0	14.0
CFV	101.8	40.6	0	0	0	62.2	204.6
PAI	4.7	5.4	0	0	0	2.6	12.7
9-11.9							
T	2.9	0	0	0	0	12.3	15.2
BA	2.0	0	0	0	0	8.0	10.0
CFV	35.9	0	0	0	0	206.9	242.8
BFV	120.9	0	0	0	0	900.4	1,021.3
PAI	1.2	0	0	0	0	6.7	7.9
12 +							
T	22.4	1.8	0	0	0	1.3	25.4
BA	26.0	2.0	0	0	0	2.0	30.0
CFV	586.8	431.0	0	0	0	68.6	698.5
BFV	2,684.6	198.7	0	0	0	344.9	3,228.2
PAI	11.9	1.9	0	0	0	1.2	14.9
TOTALS							
T	320.5	316.5	0	0	0	838.3	1,475.9
BA	38.4	14.0	0	0	0	13.9	66.2
CFV	724.4	83.7	0	0	0	337.7	1,145.8
BFV	2,805.5	198.8	0	0	0	1,245.3	4,249.6
PAI	17.8	7.2	0	0	0	10.5	35.5

Table 5

UNIT #5 CONTROL

Diameter Class	DF	WF	CBF	S	PP	ASP	Total
0-4.9							
T	340.0	90.0	0	10.0	0	620.0	1,060.0
BA	8.7	1.1	0	0.5	0	1.2	11.5
5-8.9							
T	33.0	0	0	0	0	5.9	38.9
BA	10.0	0	0	0	0	2.0	12.0
CFV	114.9	0	0	0	0	35.5	150.5
PAI	4.0	0	0	0	0	1.1	5.1
9-11.9							
T	35.2	6.7	0	0	0	2.8	44.6
BA	20.0	4.0	0	0	0	2.0	26.0
CFV	326.7	46.0	0	0	0	36.0	408.7
BFV	863.8	66.4	0	0	0	145.2	1,075.4
PAI	7.1	1.7	0	0	0	0.7	9.5
12 +							
T	31.0	0	0	0	0.8	3.1	34.8
BA	46.0	0	0	0	2.0	4.0	52.0
CFV	979.6	0	0	0	45.5	122.2	1,147.2
BFV	4,683.9	0	0	0	159.7	601.0	5,444.6
PAI	11.0	0	0	0	0.5	1.6	13.1
TOTALS							
T	439.1	96.7	0	10.0	0.8	631.8	1,178.4
BA	84.7	5.1	0	0.5	2.0	9.2	101.5
CFV	1,421.3	46.0	0	0	45.5	193.7	1,706.4
BFV	5,547.7	66.4	0	0	159.7	746.2	6,520.0
PAI	22.1	1.7	0	0	0.5	3.4	27.7

APPENDIX C

Budworm Damage Tables

The following tables, 6-10, display the intensity of western spruce budworm damage by host species and diameter class for each unit. Only host species are shown. The table values are percent of live trees per acre (%T) and percent of live basal area per acre (%BA). Current midcrown defoliation is a result of the 1980 feeding season. Top-kill greater than 10 percent of live crown or defoliation-caused mortality was not found in any unit sample.

Table 6

UNIT #1 CLEARCUT

Species/Diameter Class		CURRENT MIDCROWN DEFOLIATION				TOP KILL
		None (0%)	Light (1-25%)	Moderate (26-75%)	Severe (76-100%)	Light (<10% Live Crown)
DF						
0-4.9	%T	6	23	51	20	0
	%BA	7	0	81	12	0
5-8.9	%T	0	47	0	53	0
	%BA	0	50	0	50	0
9-11.9	%T	0	33	35	32	0
	%BA	0	33	33	33	0
12+	%T	0	26	59	14	0
	%BA	0	26	61	13	0
WF						
0-4.9	%T	0	11	63	26	0
	%BA	0	14	36	50	0
5-8.9	%T	0	0	0	100	0
	%BA	0	0	0	100	0
9-11.9	%T	0	0	0	100	0
	%BA	0	0	0	100	0
12+	%T	0	0	0	100	0
	%BA	0	0	0	100	0

Table 7

UNIT #2 SHELTERWOOD-PLANT

Species/Diameter Class		CURRENT MIDCROWN DEFOLIATION None (0%)	Light (1-25%)	Moderate (26-75%)	Severe (76-100%)	TOP KILL Light (<10% Live Crown)
DF						
0-4.9	%T	0	0	61	39	0
	%BA	0	0	0	100	0
5-8.9	%T	0	0	21	79	0
	%BA	0	0	23	77	0
9-11.9	%T	0	4	35	61	0
	%BA	0	4	33	63	0
12+	%T	0	8	43	49	0
	%BA	0	11	44	44	0
WF						
0-4.9	%T	6	6	56	31	0
	%BA	0	0	0	100	0
5-8.9	%T	--	--	--	--	--
	%BA	--	--	--	--	--
9-11.9	%T	0	0	0	100	0
	%BA	0	0	0	100	0
12+	%T	0	0	0	100	0
	%BA	0	0	0	100	0

Table 8

UNIT #3 SHELTERWOOD-ADVANCE

Species/Diameter Class		CURRENT MIDCROWN DEFOLIATION None (0%)	Light (1-25%)	Moderate (26-75%)	Severe (76-100%)	TOP KILL Light (<10% Live Crown)
DF						
0-4.9	%T	7	0	93	0	0
	%BA	0	0	100	0	0
5-8.9	%T	0	0	0	100	0
	%BA	0	0	0	100	0
9-11.9	%T	23	22	36	20	0
	%BA	20	20	40	20	0
12+	%T	0	15	85	0	0
	%BA	0	20	80	0	0
WF						
0-4.9	%T	0	20	60	20	0
	%BA	0	0	79	21	0
5-8.9	%T	0	0	75	25	0
	%BA	0	0	67	33	0
9-11.9	%T	0	0	0	100	0
	%BA	0	0	0	100	0
12+	%T	0	0	28	72	0
	%BA	0	0	33	67	0
CBF						
0-4.9	%T	--	--	--	--	--
	%BA	--	--	--	--	--
5-8.9	%T	--	--	--	--	--
	%BA	--	--	--	--	--
9-11.9	%T	--	--	--	--	--
	%BA	--	--	--	--	--
12+	%T	0	0	0	100	0
	%BA	0	0	0	100	0
S						
0-4.9	%T	0	75	0	25	0
	%BA	--	--	--	--	--
5-8.9	%T	--	--	--	--	--
	%BA	--	--	--	--	--
9-11.9	%T	--	--	--	--	--
	%BA	--	--	--	--	--
12+	%T	0	0	59	41	0
	%BA	0	0	50	50	0

Table 9

UNIT #4 OVERSTORY REMOVAL

Species/Diameter Class		CURRENT MIDCROWN DEFOLIATION None (0%)	Light (1-25%)	Moderate (26-75%)	Severe (76-100%)	TOP KILL Light (<10% Live Crown)
DF						
0-4.9	%T	0	25	64	11	21
	%BA	0	25	45	30	0
5-8.9	%T	0	0	33	68	0
	%BA	0	0	33	67	0
9-11.9	%T	0	0	100	0	0
	%BA	0	0	100	0	0
12+	%T	0	0	61	39	0
	%BA	0	0	62	38	0
WF						
0-4.9	%T	7	41	31	21	3
	%BA	2	23	60	15	0
5-8.9	%T	0	0	0	100	0
	%BA	0	0	0	100	0
9-11.9	%T	--	--	--	--	--
	%BA	--	--	--	--	--
12+	%T	0	0	0	100	0
	%BA	0	0	0	100	0

Table 10

UNIT #5 CONTROL

Species/Diameter Class		CURRENT MIDCROWN DEFOLIATION None (0%)	Light (1-25%)	Moderate (26-75%)	Severe (76-100%)	TOP KILL Light (<10% Live Crown)
DF						
0-4.9	%T	0	3	68	29	0
	%BA	0	0	72	28	0
5-8.9	%T	0	0	27	73	0
	%BA	0	0	20	80	0
9-11.9	%T	0	0	39	61	0
	%BA	0	0	40	60	0
12+	%T	0	22	52	26	0
	%BA	0	22	52	26	0
WF						
0-4.9	%T	0	33	67	0	0
	%BA	0	100	0	0	0
5-8.9	%T	--	--	--	--	--
	%BA	--	--	--	--	--
9-11.9	%T	0	0	0	100	0
	%BA	0	0	0	100	0
12+	%T	--	--	--	--	--
	%BA	--	--	--	--	--
S						
0-4.9	%T	0	0	0	100	0
	%BA	0	0	0	100	0
5-8.9	%T	--	--	--	--	--
	%BA	--	--	--	--	--
9-11.9	%T	--	--	--	--	--
	%BA	--	--	--	--	--
12+	%T	--	--	--	--	--
	%BA	--	--	--	--	--

APPENDIX D

Stand Damage Tables

The following tables, 11-15, display the amount of stand damage exclusive of western spruce budworm by species and diameter class for each unit. The table values are percent of trees per acre (%T) and percent of basal area per acre (%BA) affected. These percentages are based on live trees only for all columns except mortality which is based on total trees live and dead. Spike tops may represent budworm damage incurred during previous outbreaks.

e 11

UNIT #1 CLEARCUT

Species/ Diameter Class		DAMAGING AGENT OR CONDITION						
		Dwarf Mistletoe	Root Disease	Stem Rusts or Cankers	Stem Decays	Spike Top	Logging Damage	Mortality
DF								
0-4.9	%T	23	0	0	0		0	0
	%BA	100	0	0	0		0	0
5-8.9	%T	100	0	0	0		0	0
	%BA	100	0	0	0		0	0
9-11.9	%T	100	0	0	0		0	18
	%BA	100	0	0	0		0	14
12+	%T	94	0	0	0		0	0
	%BA	96	0	0	0		0	0
WF								
0-4.9	%T	0	0	0	0	11	0	13
	%BA	0	0	0	0	0	0	64
5-8.9	%T	0	0	0	0	48	0	30
	%BA	0	0	0	0	50	0	33
9-11.9	%T	0	0	0	29	28	28	0
	%BA	0	0	0	33	33	33	0
12+	%T	0	0	0	39	0	0	0
	%BA	0	0	0	50	0	0	0
PP								
0-4.9	%T	0	0	100	0	0	0	0
	%BA	0	0	100	0	0	0	0
5-8.9	%T	--	--	--	--	--	--	--
	%BA	--	--	--	--	--	--	--
9-11.9	%T	--	--	--	--	--	--	--
	%BA	--	--	--	--	--	--	--
12+	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0
ASP								
0-4.9	%T	0	0	5	0	0	0	0
	%BA	0	0	61	0	0	0	0
5-8.9	%T	0	0	0	0	51	0	0
	%BA	0	0	0	0	33	0	0
9-11.9	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0
12+	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0

Table 12

UNIT #2 SHELTERWOOD-PLANT

Species/ Diameter Class		Dwarf Mistletoe	Root Disease	Stem Rusts or Cankers	Stem Decays	Spike Top	Logging Damage	Mortality
		DAMAGING AGENT OR CONDITION						
DF								
0-4.9	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0
5-8.9	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0
9-11.9	%T	0	0	0	0	0	3	0
	%BA	0	0	0	0	0	4	0
12+	%T	0	0	0	0	4	0	0
	%BA	0	0	0	0	6	0	0
WF								
0-4.9	%T	0	0	0	0	12	0	0
	%BA	0	0	0	0	0	0	0
5-8.9	%T	--	--	--	--	--	--	--
	%BA	--	--	--	--	--	--	--
9-11.9	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0
12+	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0
ASP								
0-4.9	%T	0	0	0	0	2	0	0
	%BA	0	0	0	0	100	0	0
5-8.9	%T	0	0	0	0	42	0	0
	%BA	0	0	0	0	50	0	0
9-11.9	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0
12+	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0

Table 13

UNIT #3 SHELTERWOOD-ADVANCE

Species/ Diameter Class		DAMAGING AGENT OR CONDITION Dwarf Mistletoe	Root Disease	Stem Rusts or Cankers	Stem Decays	Spike Top	Logging Damage	Mortality
DF								
0-4.9	%T	0	0	14	0	0	7	0
	%BA	0	0	3	0	0	3	0
5-8.9	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0
9-11.9	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0
12+	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0
WF								
0-4.9	%T	0	0	0	0	20	0	0
	%BA	0	0	0	0	0	0	0
5-8.9	%T	0	0	0	43	57	0	21
	%BA	0	0	0	33	66	0	25
9-11.9	%T	0	0	0	0	0	0	66
	%BA	0	0	0	0	0	0	66
12+	%T	0	0	0	28	22	0	30
	%BA	0	0	0	33	33	0	25
CBF								
0-4.9	%T	--	--	--	--	--	--	--
	%BA	--	--	--	--	--	--	--
5-8.9	%T	--	--	--	--	--	--	--
	%BA	--	--	--	--	--	--	--
9-11.9	%T	--	--	--	--	--	--	--
	%BA	--	--	--	--	--	--	--
12+	%T	0	0	0	100	100	0	0
	%BA	0	0	0	100	100	0	0
S								
0-4.9	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0
5-8.9	%T	--	--	--	--	--	--	--
	%BA	--	--	--	--	--	--	--
9-11.9	%T	--	--	--	--	--	--	--
	%BA	--	--	--	--	--	--	--
12+	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0

Table 13, continued

Species/ Diameter Class		DAMAGING AGENT OR CONDITION Dwarf Mistletoe	Root Disease	Stem Rusts or Cankers	Stem Decays	Spike Top	Logging Damage	Mortality
ASP								
0-4.9	%T	0	0	15	0	0	0	0
	%BA	0	0	0	0	0	0	0
5-8.9	%T	0	0	63	0	0	0	34
	%BA	0	0	66	0	0	0	25
9-11.9	%T	0	0	0	0	37	0	0
	%BA	0	0	0	0	33	0	0
12+	%T	0	0	0	0	0	0	56
	%BA	0	0	0	0	0	0	50

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UNIT #4 OVERSTORY REMOVAL

Species/ Diameter Class		DAMAGING AGENT OR CONDITION: Dwarf Mistletoe	Root Disease	Stem Rusts or Cankers	Stem Decays	Spike Top	Logging Damage	Mortality
DF								
0-4.9	%T	0	0	0	4	7	0	0
	%BA	0	0	0	2	4	0	0
5-8.9	%T	0	0	0	0	0	0	33
	%BA	0	0	0	0	0	0	25
9-11.9	%T	0	0	100	0	0	0	0
	%BA	0	0	100	0	0	0	0
12+	%T	0	0	17	0	0	0	0
	%BA	0	0	15	0	0	0	0
WF								
0-4.9	%T	0	0	3	3	25	0	0
	%BA	0	0	2	5	33	0	0
5-8.9	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0
9-11.9	%T	--	--	--	--	--	--	100
	%BA	--	--	--	--	--	--	100
12+	%T	0	0	0	0	0	0	51
	%BA	0	0	0	0	0	0	50
ASP								
0-4.9	%T	0	0	2	0	0	0	0
	%BA	0	0	10	0	0	0	0
5-8.9	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0
9-11.9	%T	0	0	54	0	0	0	0
	%BA	0	0	50	0	0	0	0
12+	%T	0	0	100	0	0	0	0
	%BA	0	0	100	0	0	0	0

Table 15

UNIT #5 CONTROL

Species/ Diameter Class		Dwarf Mistletoe	Root Disease	Stem Rusts or Cankers	Stem Decays	Spike Top	Logging Damage	Mortality
		DAMAGING AGENT OR CONDITION						
DF								
0-4.9	%T	6	0	0	0	3	0	0
	%BA	21	0	0	0	8	0	0
5-8.9	%T	63	0	0	0	0	0	0
	%BA	60	0	0	0	0	0	0
9-11.9	%T	76	0	0	0	0	0	0
	%BA	70	0	0	0	0	0	0
12+	%T	91	0	0	0	7	0	0
	%BA	83	0	0	0	9	0	0
WF								
0-4.9	%T	0	0	11	0	22	0	0
	%BA	0	0	45	0	55	0	0
5-8.9	%T	--	--	--	--	--	--	--
	%BA	--	--	--	--	--	--	--
9-11.9	%T	0	0	0	46	0	0	0
	%BA	0	0	0	50	0	0	0
12+	%T	--	--	--	--	--	--	--
	%BA	--	--	--	--	--	--	--
S								
0-4.9	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0
5-8.9	%T	--	--	--	--	--	--	--
	%BA	--	--	--	--	--	--	--
9-11.9	%T	--	--	--	--	--	--	--
	%BA	--	--	--	--	--	--	--
12+	%T	--	--	--	--	--	--	--
	%BA	--	--	--	--	--	--	--
PP								
0-4.9	%T	--	--	--	--	--	--	--
	%BA	--	--	--	--	--	--	--
5-8.9	%T	--	--	--	--	--	--	--
	%BA	--	--	--	--	--	--	--
9-11.9	%T	--	--	--	--	--	--	--
	%BA	--	--	--	--	--	--	--
12+	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0

le 15, continued

Species/ Diameter Class		Dwarf Mistletoe	Root Disease	Stem Rusts or Cankers	Stem Decays	Spike Top	Logging Damage	Mortality
		DAMAGING AGENT OR CONDITION						
ASP								
0-4.9	%T	0	0	2	0	2	0	0
	%BA	0	0	0	0	42	0	0
5-8.9	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0
9-11.9	%T	0	0	0	0	0	0	0
	%BA	0	0	0	0	0	0	0
12+	%T	0	0	55	0	0	0	0
	%BA	0	0	50	0	0	0	0

APPENDIX E

Stand Examination Methods

Timber stand parameters are estimated by a systematic sample of stand examination plots for each treatment unit including the control. Approximately 10 sample plots are located in each unit on a square spacing layout. All stand measurements are taken in late summer after budworm feeding is complete and tree height growth has terminated for the season.

Stand examination plots consist of a variable radius plot (BAF 20) for tallying trees ≥ 5.0 inches d.b.h. and a fixed radius plot (1/100 acre) for tallying trees < 5.0 inches d.b.h. Such plots conform to the revised R-3 field procedures for operational stand examinations. Data recorded for all tally trees includes the following: species, d.b.h., height, damaging agents, live crown class or position, and tree history. Tree age is determined for a representative sample of conifers in all crown positions. Ten-year radial increments are measured on a subsample of conifers ≥ 3.0 inches d.b.h. stratified by species and 2-inch diameter classes. For conifers < 3.0 inches d.b.h., current year's height growth and past 5 year's height growth are measured on a subsample stratified by species and diameter (< 1.0 inch d.b.h. or 1.0 to 2.99 inches d.b.h.). The 6-class dwarf mistletoe rating system (Hawksworth 1977) is used to quantify infections on Douglas-fir. All host trees of the western spruce budworm, except those which display thinning crowns from root disease, are rated for defoliation according to the following classes:

0 - no defoliation
1 - 1-25 percent defoliated
2 - 26-50 percent defoliated
3 - 51-75 percent defoliated
4 - 76-99 percent defoliated
5 - 100 percent defoliated

An ocular estimate, using binoculars, of current year's defoliation is recorded for each third of the live crown length. For seedlings < 1.0 inch d.b.h. a single rating is recorded as an average for the entire crown. Cumulative past defoliation is also estimated at midcrown using the same classes. The ocular estimate of current defoliation is calibrated by actually measuring defoliation on a midcrown sample branch cut from selected reachable host trees in all canopy levels. Twenty-five apical shoots along one side of the sample branch are scored 0 through 5 according to the defoliation classes.

Average defoliation is then computed based on class midpoints. The length of dead top, and whether or not it is attributable to the current infestation, is also recorded for all budworm host trees.

APPENDIX F

Insect Sampling Procedures

I. Selection of Sample Trees

On each of the five demonstration units, 10 dominant-codominant Douglas-fir trees, 30 to 50 feet in height and relatively open-grown with full crowns, were selected for sampling. Sample trees were located as close to stand examination plot centers as possible. Plot centers were established systematically using a 10-point sampling grid. Distances between plot centers were determined by the size of the unit being sampled.

Douglas-fir seedlings and saplings were also sampled on each stand examination plot, when available.

II. Larval Sampling

Larval sampling began when 20 percent of the larvae were in the fifth instar or larger. Actual population distribution between instars, according to the sample, is reported in Table 16 at the end of this section. On each dominant-codominant sample tree, two 15-inch branches were cut from opposite sides of the midcrown using a pole pruner with attached collecting bag. The length and width of each branch were recorded to determine the foliated branch surface area.

Each branch sampled was positioned over a drop cloth and beat with a stick until all the larvae were dislodged; larvae in the collecting bag were removed by inverting the bag over the drop cloth and vigorously shaking it. The larvae were counted and preserved in ethyl alcohol. One bottle was used to preserve all the larvae collected from the 10 sample trees in each unit.

Bottles containing the preserved larvae were then labeled with the appropriate unit and collection date. Total numbers of larvae and live buds per 15-inch branch were counted and recorded.

Seedlings ranging from 1.5 to 3 feet tall were sampled by bending them over a drop cloth and beating them with a stick until all larvae were dislodged. The larvae and total number of live buds were counted and recorded. Saplings, ranging from 1 inch to 4.99 inches in d.b.h. were sampled by removing two branches from the midcrown using a pole pruner with attached collecting bag. Each branch was then positioned over drop cloth as previously described. The larvae and number of live buds per branch were counted and recorded, and then discarded.

Table 16. Western Spruce Budworm Larval Instar Distribution, Pre-treatment Samples, Western Spruce Budworm Demonstration Area, Carson National Forest.

Treatment Units	Sampling Date(s)	Number of Budworm						
		Larval Instars						
		II	III	IV	V	VI	Pupae	Total
#1	6/23-24/80	0	6	21	15	16	0	58
#2	6/22-23/80	0	9	34	18	41	0	102
#3	6/19-20/80	0	28	100	32	7	0	167
#4	6/21-22/80	0	11	23	48	21	0	103
#5	6/20-21/80	0	6	21	15	16	0	48
Totals		0	60	199	128	101	0	488
Percentile		0%	12%	41%	26%	21%	0	100%

III. Egg Mass Sampling

Egg masses on overstory trees were sampled by cutting two 70 cm branches from opposite sides of each sample tree. Branches were cut using a pole pruner. The length and width of each branch were measured to calculate foliated branch surface area. Each branch was then individually bagged in a 1/4-bushel cloth sack, labeled, transported to the laboratory, and stored in a walk-in cooler at 40° F prior to examination.

Foliage was examined under ultraviolet light for egg masses. Needles bearing egg masses were classed as from current year's foliage or previous year's and kept in separate pill boxes. New egg masses were separated from old egg masses under a stereomicroscope. All egg masses on current year's foliage were classed as new and their characteristics used to form the basis for aging those egg masses found on a previous year's foliage.

Egg masses on seedlings and saplings[1/] were sampled by cutting one branch from their respective midcrowns. Each branch was tagged and individually bagged. Each branch was examined for egg masses as previously described.

1/ Egg mass data on seedlings and saplings were collected and analyzed by personnel from the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.